

Rat Control Research in Macadamia Nut Orchards

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Macadamia nut orchards in Hawaii provide an ideal habitat for rats. Mature trees form thick canopies that provide nesting sites and interlocking branches that facilitate the safe movement of rats among trees. Wind breaks, interior waste areas, and adjacent noncrop areas also provide harborage and food. The lava rock substrate in orchards forms natural ground cavities and crevices where rats can burrow and nest beneath the orchard floor. The high oil content of mature nuts are a rich source of energy. Nuts at various stages of development are available throughout the year, thus providing rats an almost continuous supply of nuts.

Rats damage an estimated 5-10% of the annual macadamia nut crop in Hawaii, causing farm losses ranging from about \$2-4 million. Damage occurs throughout the crop cycle, from the time kernels are small, fleshy, unprotected fruits to when they are fully developed and surrounded by husks and hard, brittle shells. The majority of damage occurs in trees, with only limited foraging occurring on fallen nuts. In spite of their impact, little is known about these pests in and around orchards, and few methods are available for controlling damage.

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The U.S. Department of Agriculture's Animal and Plant Health Inspection Service maintains a research facility in Hilo to develop, evaluate, and improve methods of controlling rodent damage to Hawaiian agricultural crops, and to develop biological and ecological data needed for effective use of new and existing control methods. The Hilo Field Station is a unit of the Denver Wildlife Research Center (DWRC), the federal organization responsible for wildlife damage control research in the United States. Work at the Hilo facility focuses on sugarcane and macadamia nuts. Previous efforts at the laboratory led to the registration of zinc phosphide for use in these two crops.

The Hilo staff currently is involved in a number of laboratory and field studies to learn more about the control of rats in macadamia nut orchards. This paper gives a brief overview of our research in macadamia nut orchards.

We recently completed field work for a 2-year cooperative project with Mauna Loa Macadamia Nut Corporation to evaluate rodent trapping as a potential control method. Trapping is too labor-intensive to be practical for most large-scale agricultural situations, but it may be cost-effective for protecting high value crops such as macadamia nuts.

The study was conducted in 4 orchard blocks encompassing 40-50 ac each and containing 97 twenty-year-old macadamia nut trees

per acre. We randomly selected half of each block for in-tree placement of 8-10 traps/ac, and used the other half for comparison. At approximately 6-wk intervals, during the week following each scheduled harvest and once or twice during the nonharvest season, we baited the traps with chunks of coconut, secured them to lower lateral branches, and checked them daily for 2 wk. We shut down the traps on weekends and rebaited them with fresh coconut on Monday of the second week. During the second year, we checked and rebaited the traps only once, at the beginning of the second week. We removed carcasses and rebaited traps as necessary. We recorded the sex, age, weight, body length, reproductive condition, and (for females) number of embryos of each rat. We removed and froze the stomachs for later analysis of their contents to determine the diet of orchard rats throughout the crop cycle.

During the first year of the study, we captured 1,704 rats, including 1,681 roof rats, 22 Polynesian rats, and 1 Norway rat. Trap success in each block declined to less than 5 rats by the end of each 2-wk session, but rats usually reinvaded rapidly and quickly dispersed throughout the block by the next trapping session. Trap success declined steadily over the course of the first year and remained low during the second year of the study. During 1991-92 we removed only 360 rats in the 4 blocks. However, during the second year carcasses remained in traps for up to a week, and we do not know how many were removed by

mongooses (Herpestes auropunctatus) and other predators.

Damage was significantly lower in the trapped sections than in the reference sections. During the 1990-91 crop season, damage was 67 % lower in the trapped sections than in the reference sections. During 1991-92, damage reduction due to trapping was 73 %.

Interestingly enough, the reduced damage did not result in increased yields. During both years of the study, yields were slightly, though not significantly, lower in the trapped sections. The reason that the lower damage apparently did not result in increased yields is unclear. Compensatory growth may have been a factor: heavily damaged trees might have produced more or larger nuts or retained a higher proportion of nuts that would have aborted naturally. An alternative explanation is that rat damage was too low to have a detectible effect on yields.

During 1991 we also initiated a radio telemetry study to determine nightly movement patterns of rats in a macadamia nut orchard, to detect seasonal differences in these movements, and to relate seasonal differences to the abundance and maturity of nuts. Alan Yamaguchi, Gary Ueunten, and their staff at Mauna Loa Macadamia Nut Corporation helped conduct the study.

The study was conducted during 3 periods of the crop cycle:

peak anthesis, peak immaturity (when most nuts are >110 days old, full-sized, but with low oil content and without shells), and peak maturity (when nuts are >200 days old, full-sized, and with shells). During each of these periods, we captured approximately 20 roof rats, fit them with collar radio transmitters, and monitored their nightly movements during 9 nightly tracking sessions over the course of 3 wk. During each nightly tracking session, we determined the location of each collared rat at 2-hr intervals between sunset and sunrise. We took occasional daytime readings to monitor diurnal activity, locate nests and daily resting places, and confirm suspected mortality.

We tracked 20 rats during peak anthesis, 24 rats during anthesis, and 18 rats during peak harvest. Most of the rats remained in underground burrows during the day, emerged shortly after sunset to feed in the canopy, and returned to their burrows shortly before sunrise. A few rats nested in trees during the day. During peak harvest most rats stayed within 5-10 trees of their daily resting burrows. Nightly movements seem to be more extensive during peak flowering and peak immaturity, perhaps in response to the reduced availability of nuts.

We observed only limited movement between the orchard and surrounding windbreaks. Some of the rats in windbreaks foraged in trees along the perimeter of the orchard, but we did not observe any of the rats captured in the orchard venture into

surrounding windbreaks or noncrop areas. Thus, even during periods of low nut availability, rats apparently find sufficient food within orchards to sustain themselves.

The results from this study should help managers devise more effective strategies for controlling rats in macadamia nut orchards. Knowledge of seasonal and nightly movement patterns of rats in orchards could help determine optimum timing and placement of rodenticide baits, traps, or other control measures.

A major objective at the Hilo lab is to find safer and more effective methods for using agricultural rodenticides. We conduct laboratory efficacy tests to evaluate candidate and registered rodenticides for controlling rats. Norway rats and Polynesian rats are the main pests in sugarcane fields; roof rats are the species of concern in macadamia nut orchards. We routinely conduct tests with all 3 species.

Zinc phosphide-treated oats, the bait most commonly used to control rats in macadamia nut orchards and sugarcane fields, rapidly lose their potency under the wet and humid conditions present in much of Hawaii. We recently conducted laboratory tests to evaluate a zinc phosphide waxed bait block that might be more weather-resistant than zinc phosphide oat baits.

We offered either Ridall-Zinc² Bait Block (a waxed 2.0 % zinc phosphide grain bait made by Lipha Tech, Inc.) or zinc phosphide-treated oats to individually caged rats during 3-day no-choice feeding trials. The results indicate that both formulations are effective for roof rats and Polynesian rats, but not for Norway rats. Field testing is needed to evaluate Ridall-Zinc Bait Block for controlling roof rat damage in macadamia nut orchards.

We will never eliminate rats completely from macadamia nut orchards; they are in Hawaii to stay. However, we can learn to manage our problems better. This paper has given a sampling of some of the rat control research being conducted at the DWRC Hilo field station. Hopefully the results will help growers manage rats in a more cost-effective manner.

²Reference to commercial products does not imply endorsement by the author or the U.S. Department of Agriculture.